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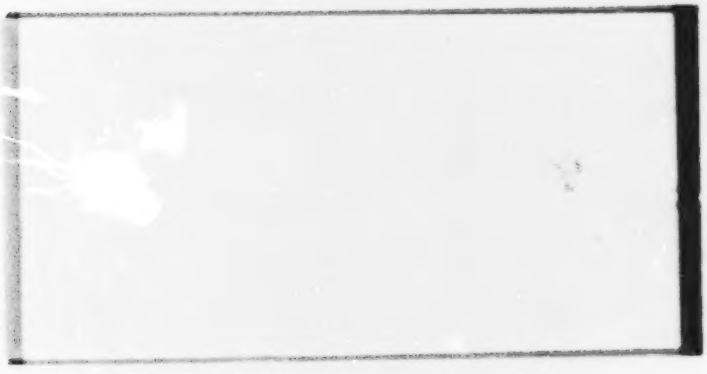

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ASSESSMENT OF ROCK SLOPE STABILITY - ABITIBI CANYON GS

Report No 84-431-K

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ABSTRACT

A rock cliff stability assessment was undertaken at Abitibi Canyon GS to determine whether or not the slopes are safe with respect to potential rock falls and to indicate remedial measures or monitoring where applicable. Based on this investigation, remedial works are required on the east powerhouse wall and monitoring of a rock wedge north of the powerhouse is recommended.

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TABLE OF CONTENTS

	Page
1.0 INTRODUCTION	1
2.0 ROCK SLOPE ASSESSMENT	1
2.1 East Powerhouse Slope	1
2.1.1 Remedial Measures	2
2.2 West Powerhouse Slope	2
2.2.1 Remedial Measures	3
2.3 East Tailrace Slope	3
2.3.1 Remedial Measures	4
2.4 West Powerhouse Slope	4
2.4.1 Remedial Measures	4
3.0 SUMMARY OF REMEDIAL RECOMMENDATIONS	4
3.1 East Powerhouse Slope	4
3.2 West Powerhouse Slope	5
3.3 East Tailrace Slope	5
3.4 West Tailrace Slope	5
4.0 CONCLUSION	5
FIGURE 1 Plan View of Abitibi Canyon GS	6
FIGURE 2 Rock Block on East Powerhouse Wall Separated by Large Vertical Open Joint	7
FIGURE 3 Blocky Rock Mass Above Tailrace West Wall and Talus on Tailrace Deck	8
FIGURE 4 Large Rock Wedge Separated by Faults on East Tailrace Wall	9
FIGURE 5 Crack in Retaining Wall Above West Powerhouse Slope Caused by Fault Movement	10
FIGURE 6 Cracks in Spillway West Wall Probably Caused by Fault Movement	11
FIGURE 7 Cracks in Spillway West Wall Probably Caused by Fault Movement	12
FIGURE 8 Cracks in Spillway West Wall Probably Caused by Fault Movement	13
APPENDIX A - Sheet Maps E1 to E6 and W1 to W4	14
DISTRIBUTION	- last page -

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ASSESSMENT OF ROCK SLOPE STABILITY - ABITIBI CANYON GS

1.0 INTRODUCTION

An assessment of rock slope stability was undertaken at Abitibi Canyon GS during the period from September 10 to 17, 1984. In general, the geological investigation was divided into four segments. These consisted of the east and west walls above the powerhouse roof and the east and west slopes extending from the powerhouse roof to a distance of approximately 400 metres downstream. Each section was photographed to produce overlapping pictures and mapped with the aid of binoculars. The resulting information has been reproduced on map sheets to highlight certain geological features (Appendix A). The location of the various sheets are shown on the aerial photograph of Abitibi Canyon GS and its surrounding area (Figure 1). The overall intent of this program was to determine whether or not the slopes are safe with respect to potential rock falls and to indicate remedial measures or monitoring where applicable.

2.0 ROCK SLOPE ASSESSMENT

2.1 East Powerhouse Slope

The east powerhouse cliff (sheets E1, E2 and E3) was mapped in detail since it appeared to be the most critical slope judging from the amount of rock fall at its base (Figure 2). It is also located in an area which could pose a potential danger to both workers and equipment (ie transformers) on the powerhouse roof.

It can be noted on sheets E1, E2 and E3 that several zones of loose and questionable rock blocks occur scattered over the rock face. These zones are not of major concern and would most likely remain contained within the wire meshing should they become dislodged. The zone of most concern is located in the middle of the rock face and contains a major vertical joint oriented at 347/90° (Figure 2). The joint is open up to 15 cm thereby permitting water to move freely through the highly jointed rock mass. Freezing of water-filled fractures results in jacking and the eventual movement of rock blocks in this zone.

2.1.1 Remedial Measures

It is recommended that the large rock block which is separated from the face by a major joint be taken down. This would require removal of the wire meshing in that area and scaling of the face to remove loose rock to ensure safety to the workers. Vegetation should also be removed since roots contribute to rock block jacking. A timber barracade or reasonable facsimile should be erected at the base of the slope to protect the powerhouse roof and equipment during scaling procedures. It is suggested that the large rock block be removed using non-explosive methods such as mechanical splitting systems. Three such methods include the hydraulic splitter, the wedge and feather and the rock/concrete breaker developed by the Rock Sciences Section (Civil Research). The first two techniques require the operator to stand close to the zone of rock breakage which has proven to be very dangerous. The last method allows rock breaking from a safe distance. All methods require drilling of 4 cm (1.5 inch) diameter percussion holes. Rock talus at the bottom of the slope can also be split using the same procedures.

The most effective means of access to the slope would be with the aid of a crane and skip-box. This would require lowering the crane to the flat area above the rock slope. Two possibilities of doing this are: 1) lowering a crane in parts from the top of the dam using a second crane or 2) lowering a crane in parts using a helicopter.

Overhead power lines on the east powerhouse roof may be of some concern with respect to crane operator safety. It does appear, however, that most of the slope can be accessed with reasonable clearance from the power lines. Even though the remainder of the slope does not appear to be of major concern with respect to damaging rock fall, it would be logical to scale the complete slope since the equipment will be readily available. It would be advisable at this time to check the wire mesh timber support system for decay.

2.2 West Powerhouse Slope

The west powerhouse cliff was mapped in less detail than the east wall since the former appears to be in fairly good shape (sheets W1 and W2). A few areas of loose and questionable rock blocks have been indicated, but are not of major concern at this time and should be contained by the wire meshing.

A dangerous situation exists at the north end of the powerhouse roof above the tailrace deck (Figure 3). The wire meshing stops short of this area and leaves the rock face exposed from top to bottom. A discussion with the plant's mechanical foreman revealed that both rock and ice fall from this portion of the slope. This is a direct result of water draining from the edge of the power-

house wall. Freezing of the water causes ice blocks to form and jacking of rock blocks in the winter. Figure 3 shows the drainage channel at the top of the concrete wall, the loose blocky nature of the bedrock and the rock talus on the tailrace deck.

2.2.1 Remedial Measures

No work is required on the west powerhouse wall at this time except in the area above the tailrace roof. It is recommended that the drainage water on the edge of the powerhouse be diverted to the diversion tunnel which exists just north of the tailrace. A 7.6cm (3 inch) diameter percussion borehole could be drilled from the bottom of the drainage ditch at an angle to intersect the tunnel which presently appears to drain water from a vertical shaft beside the roadway above it. A PVC slotted pipe grouted into the top of the borehole and surrounded with gravel would filter out large foreign debris. A small concrete retaining wall built at the edge of the powerhouse would keep the water from draining over the edge.

Loose rock on the exposed slope could best be removed by using a crane and skip-box and working from the roadway above. As a further safety precaution, wire meshing should be extended and lengthened in this zone. Another item which should be considered is the construction of a roof using I-beams overtop of the doorway leading to the tailrace deck. At this there is no overhead protection for the workers in this area.

2.3 East Tailrace Slope

This slope shows some areas of loose and questionable rock blocks but overall does not seem to pose an immediate problem with respect to large rock block movement (sheets E4, E5 and E6). At first glance the large rock nose located approximately 100 metres north of the powerhouse appeared to be questionable, but upon closer examination with binoculars it seems to be an intact unit with the main slope. In other words, no major joints were noted to separate this rock block from the main rock face.

The rock wedge shown in sheet E4 (Figure 4) and separated by two faults was examined and determined to be an area which should be monitored. The fault was traced back to the retaining wall at the edge of the road on the west side of the station and to the concrete spillway wall east of the station. In both cases cracking of the concrete was noted. Cracks on the west wall retaining wall are shown in sheet W1 and Figure 5. Cracks in the spillway wall are shown in Figures 6 and 7.

A second fault located just north of the powerhouse (sheet E4) appears to have cracked the concrete spillway wall approximately 100 metres north of the spillway superstructure. These cracks are shown in Figure 8. Figure 1 shows assummed and approximate fault lineations based on 1) the Abitibi Canyon GS Extension drawing no 992 DXH 10120 0165, 2) memo to D.T. Ireson entitled "Abitibi Canyon Generating Station Tailrace Rock Condition", (August 21, 1951) and 3) this study.

2.3.1 Remedial Measures

No remedial measures are recommended for the east tailrace slope. It is suggested, however, that the wedge-shaped block be instrumented and monitored. Methods involving manual reading of instruments are most economical but are also most difficult and dangerous to carry out, especially during the winter-spring seasons when most of the movement can be expected due to freeze-thaw actions. It is therefore suggested that remote monitoring of the wedge be undertaken. This would involve drilling two NX diameter boreholes at an angle to intersect both fault planes and into the more stable block below. It is suggested that a multi-point extensometer be placed in one borehole, while permanently installed inclinometers be installed in the other. The former would indicate raising or lowering of the block, while the latter would indicate lateral movement. Data would be fed into the powerhouse and stored in a data logger, which could be accessed over a phone modem at any time.

2.4 West Tailrace Slope

This slope has some areas of questionable rock blocks but overall does not appear to be of major concern with respect to large rock falls at this time (sheets W2,W3 and W4).

2.4.1 Remedial Measures

None suggested.

3.0 SUMMARY OF REMEDIAL RECOMMENDATIONS

3.1 East Powerhouse Slope

a) Removal of rock block separated by large open vertical joint.
b) General scaling of remaining rock face.
c) Rockbolting if and where necessary.
d) Inspection of wire mesh support timbers.
e) Breaking and removal of talus.

3.2 West Powerhouse Slope

a) Drilling of NX percussion drainage hole from powerhouse edge to diversion tunnel and installing drain.
b) Building of small retaining wall to eliminate water seepage over edge of powerhouse.
c) Extension of wire meshing above tailrace deck.
d) Construction of steel roof above tailrace doorway.

3.3 East Tailrace Slope

a) Drilling two NX boreholes to intersect fault planes and installation of extensometers and inclinometers for remote readout.

3.4 West Tailrace Slope

a) No remedial work recommended.

4.0 CONCLUSION

The rock slopes at Abitibi Canyon GS were divided into four sections, photographed and mapped with emphasis placed on slope stability. Suggested remedial measures and monitoring recommendations have been provided with respect to all four segments where applicable. It should be emphasized that most of the information provided in this report has been obtained from a distance with binoculars and is therefore based on the best judgement possible under those conditions.

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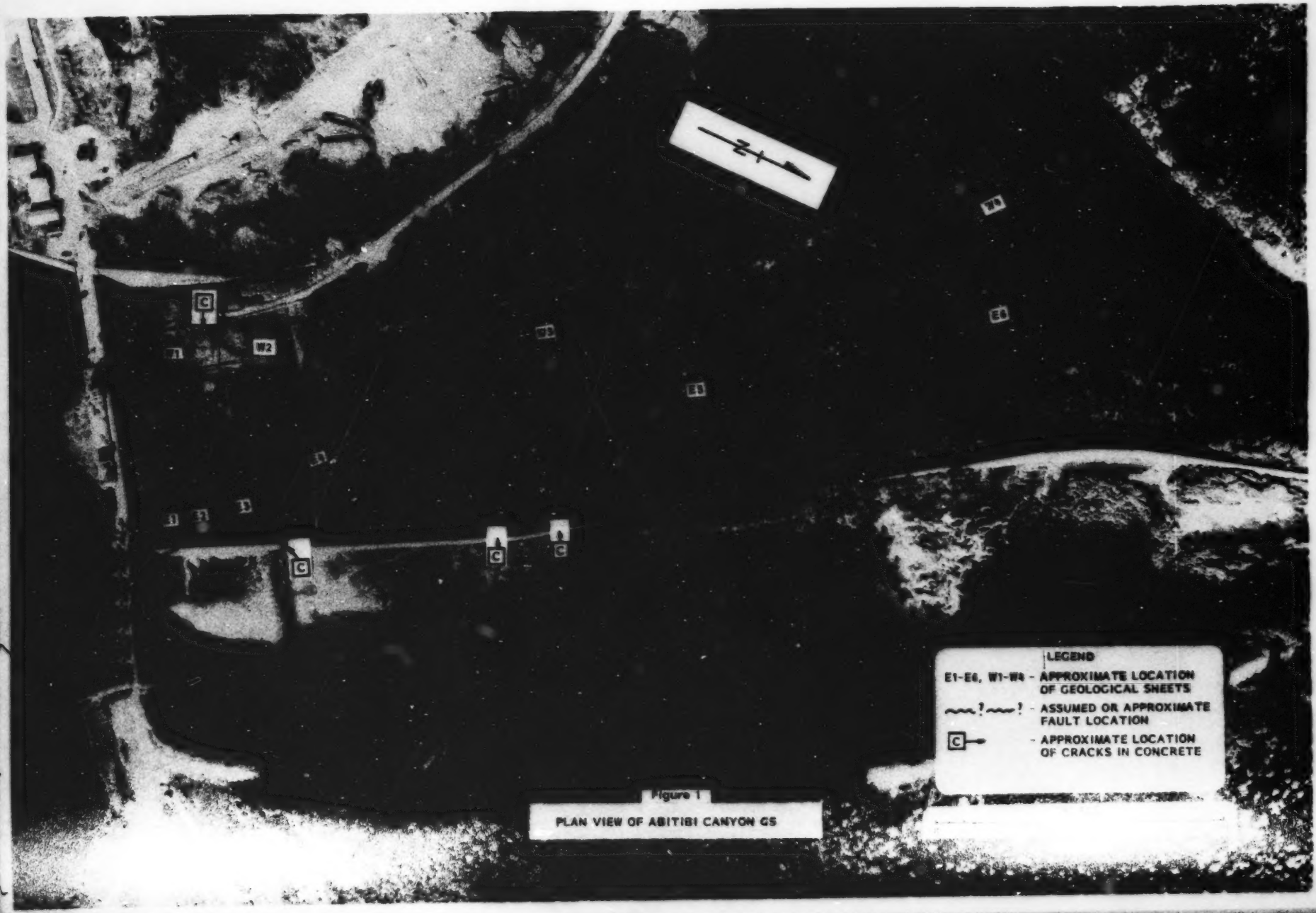

W2
E1
LEGEND
E1-E6, W1-W4 - APPROXIMATE LOCATION OF GEOLOGICAL SHEETS
~?~! - ASSUMED OR APPROXIMATE FAULT LOCATION
C - APPROXIMATE LOCATION OF CRACKS IN CONCRETE

Figure 1

PLAN VIEW OF ABITIBI CANYON GS

FIGURE 2

ROCK BLOCK ON EAST POWERHOUSE WALL SEPARATED
BY LARGE VERTICAL OPEN JOINT

FIGURE 3

BLOCKY ROCK MASS ABOVE TAILRACE WEST WALL
AND TALUS ON TAILRACE DECK

FIGURE 4

LARGE ROCK WEDGE SEPARATED BY FAULTS
ON EAST TAILRACE WALL

FIGURE 5

CRACK IN RETAINING WALL ABOVE WEST POWERHOUSE
SLOPE CAUSED BY FAULT MOVEMENT

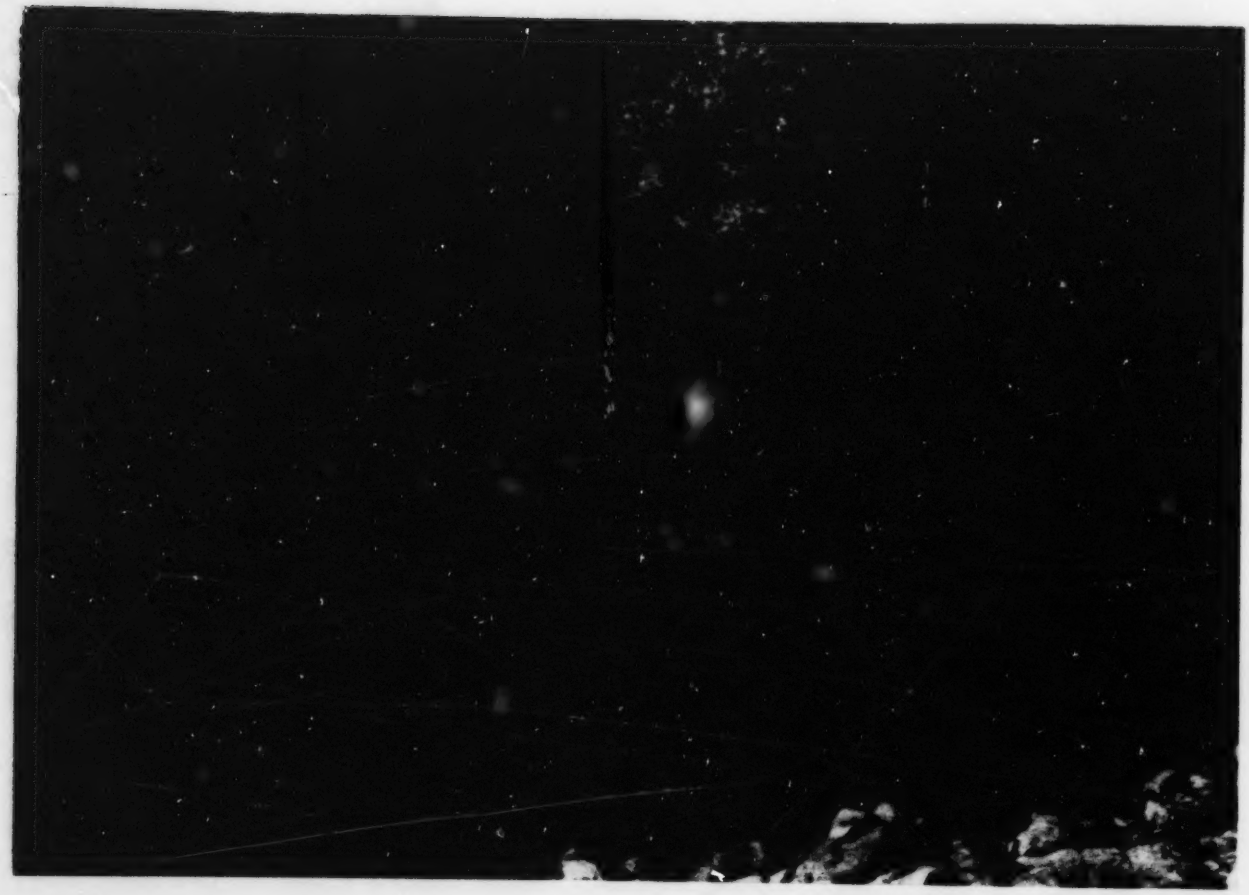


FIGURE 6

CRACKS IN SPILLWAY WEST WALL PROBABLY
CAUSED BY FAULT MOVEMENT

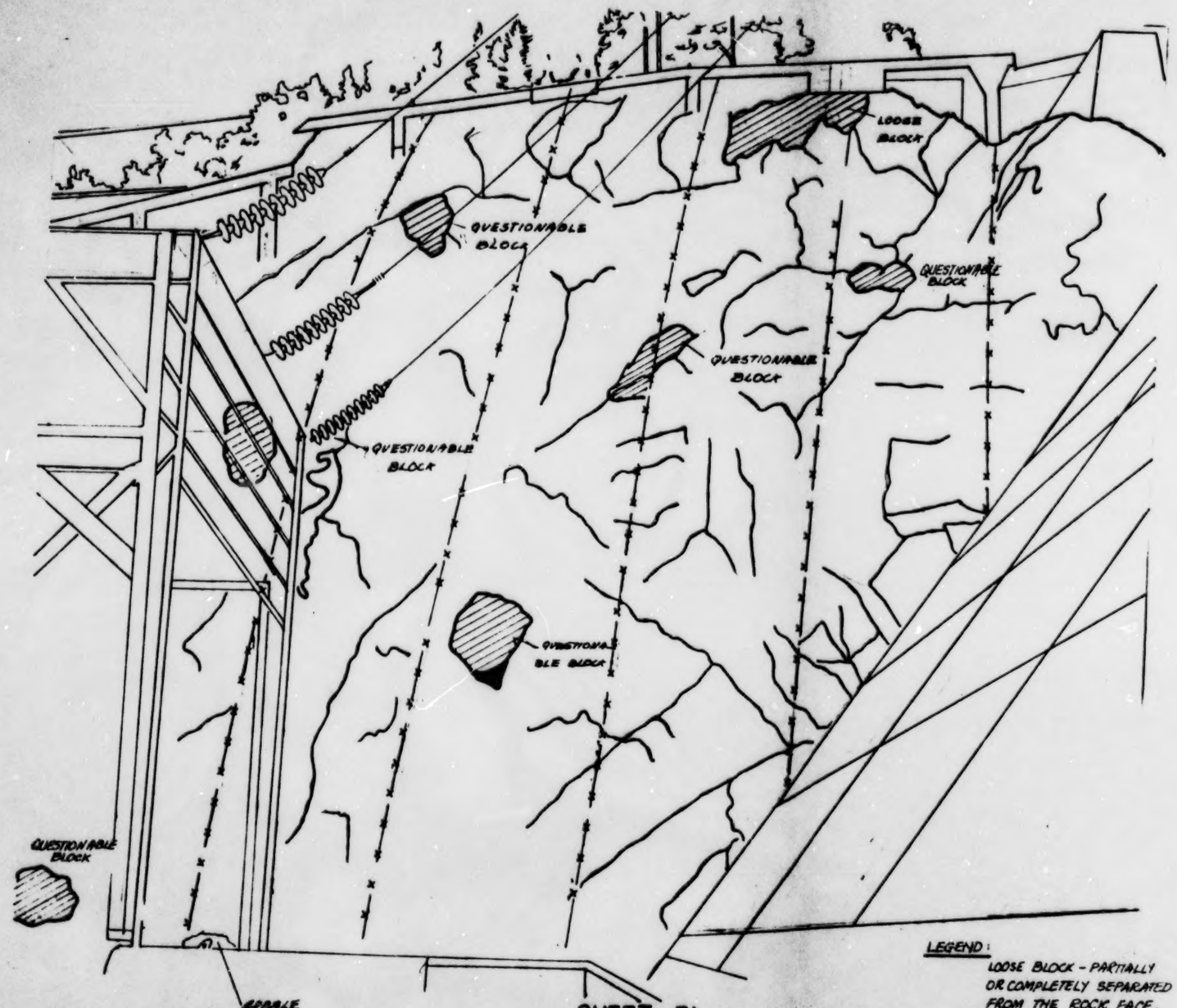
FIGURE 7

CRACKS IN SPILLWAY WEST WALL PROBABLY
CAUSED BY FAULT MOVEMENT

FIGURE 8

CRACKS IN SPILLWAY WEST WALL PROBABLY
CAUSED BY FAULT MOVEMENT

APPENDIX A



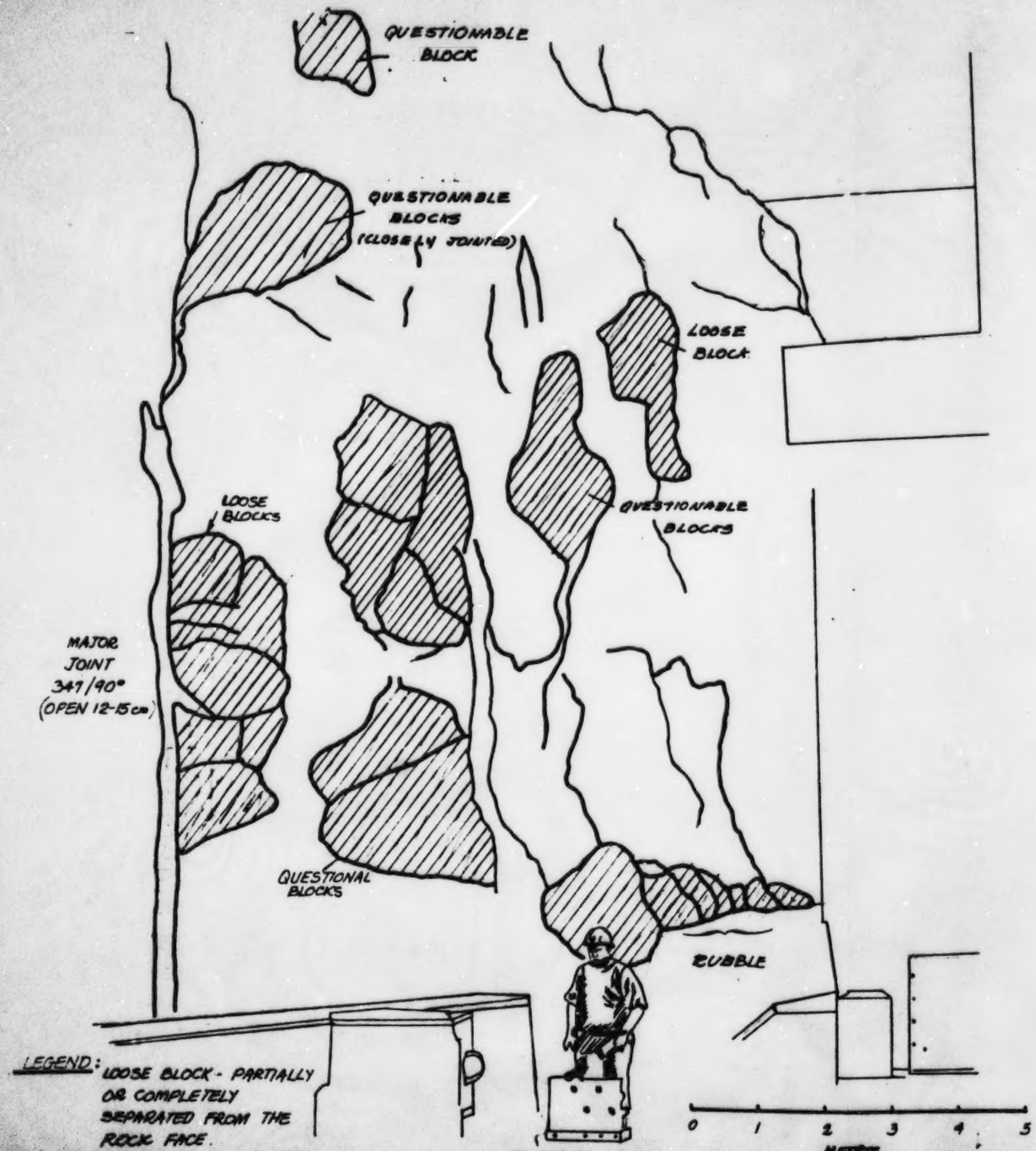
SHEET - E1

ABITIBI CANYON GS

EAST POWERHOUSE WALL

LEGEND :

LOOSE BLOCK - PARTIALLY OR COMPLETELY SEPARATED FROM THE ROCK FACE.
QUESTIONABLE BLOCK - PROTRUDING BLOCK WHICH MAY OR MAY NOT BE SEPARATED FROM THE MAIN ROCK FACE



LEGEND: LOOSE BLOCK - PARTIALLY OR COMPLETELY SEPARATED FROM THE ROCK FACE.

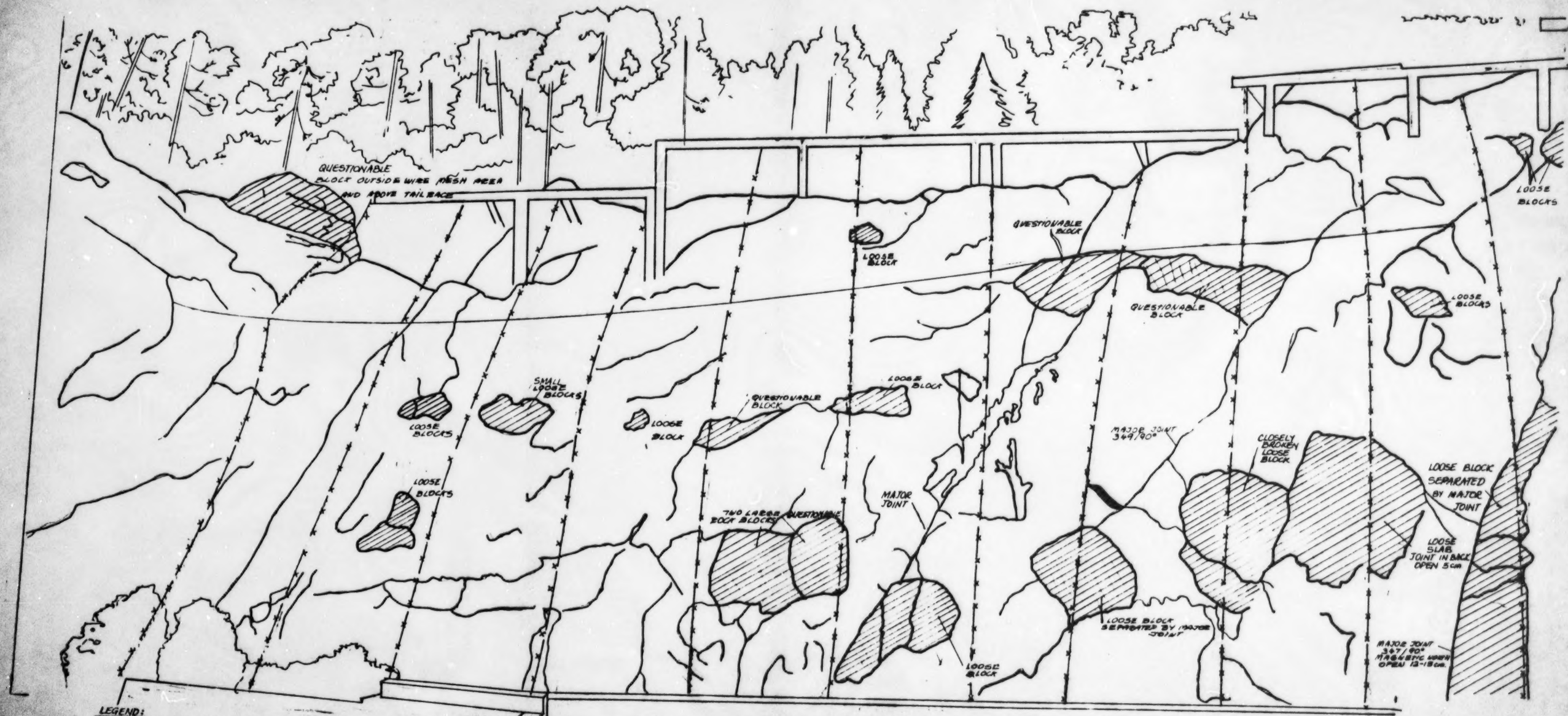
QUESTIONABLE BLOCK - PROTRUDING BLOCK WHICH MAY OR MAY NOT BE SEPARATED FROM THE MAIN ROCK FACE.

SHEET-E2

ABITIBI CANYON G S

EAST POWERHOUSE WALL

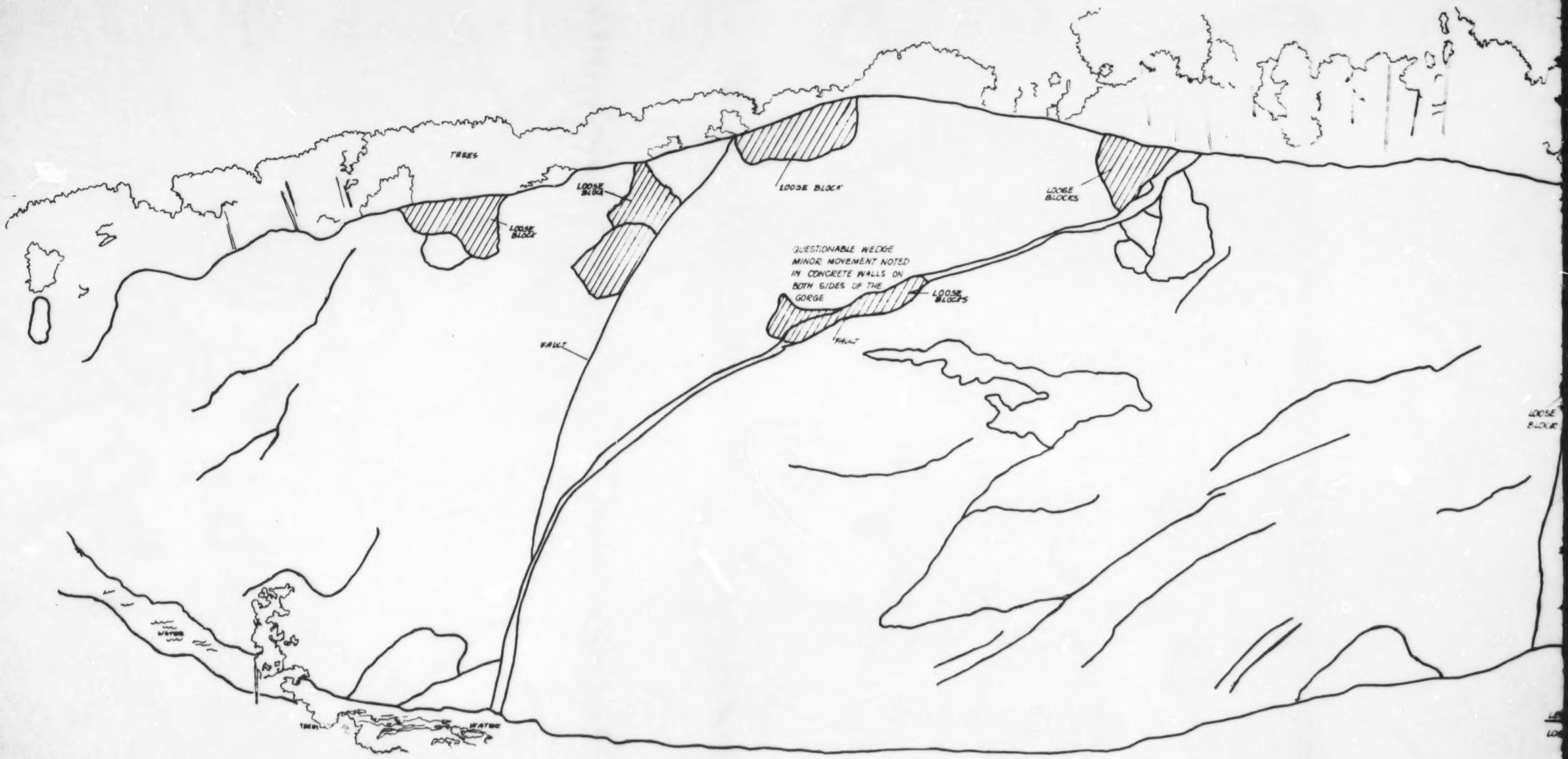
8732


QUESTIONABLE BLOCK OUTSIDE WIRE MESH AREA AND ABOVE TAILRACE
LOOSE BLOCKS
SMALL LOOSE BLOCKS
LOOSE BLOCKS
LOOSE BLOCKS
LOOSE BLOCK
QUESTIONABLE BLOCK
LOOSE BLOCK
MAJOR JOINT
TWO LARGE ROCK BLOCKS QUESTIONABLE
LOOSE BLOCK
QUESTIONABLE BLOCK
QUESTIONABLE BLOCK
LOOSE BLOCKS
LOOSE BLOCKS
MAJOR JOINT 349/90°
CLOSELY BROKEN LOOSE BLOCK
LOOSE BLOCK SEPARATED BY MAJOR JOINT
LOOSE SLAB, JOINT IN BACK OPEN 5cm
LOOSE BLOCK SEPARATED BY MAJOR JOINT
MAJOR JOINT 347/90° MAGNETIC NORTH OPEN 12-15cm.
LEGEND:
LOOSE BLOCK - PARTIALLY OR COMPLETELY SEPARATED FROM THE ROCK FACE
QUESTIONABLE BLOCK - PROTRUDING BLOCK WHICH MAY OR MAY NOT BE SEPARATED FROM THE MAIN ROCK FACE
WIRE MESH SEAMS
0 1 2 3 4 5
METRES
(APPROXIMATE SCALE)

SHEET-E3

ABITIBI CANYON GS

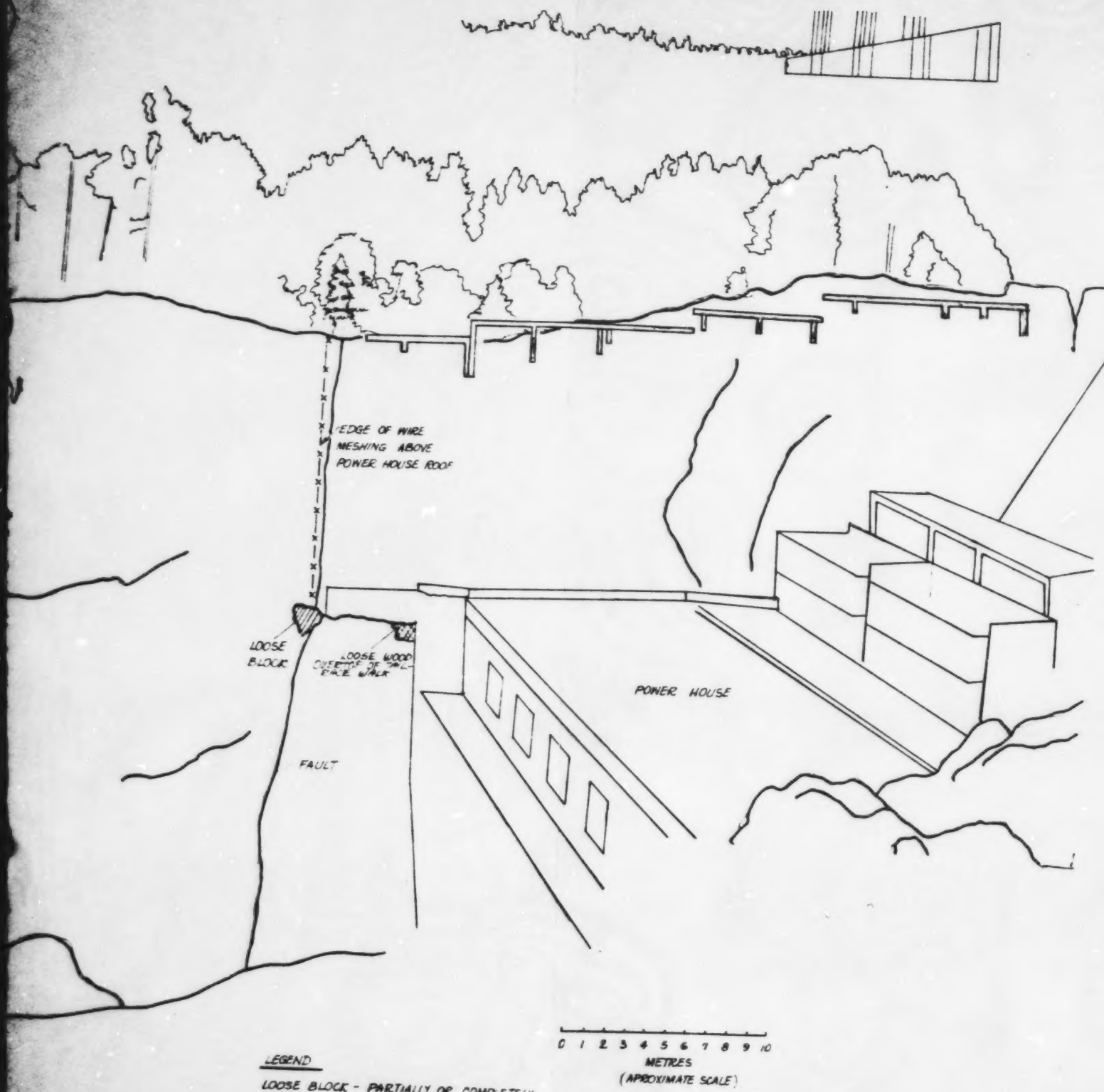
EAST POWERHOUSE WALL



SHEET-E4

ABITIBI CANYON G S

EAST TAILRACE WALL

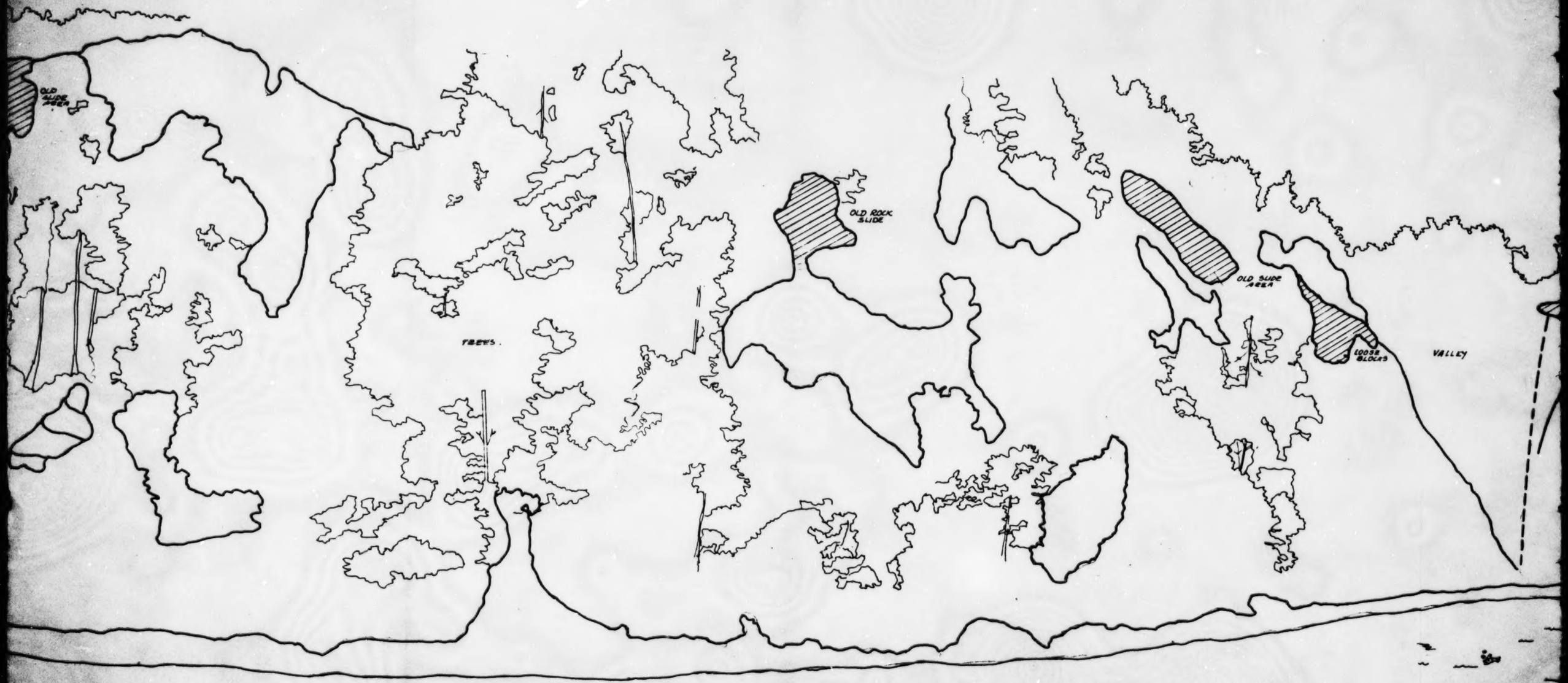

EDGE OF WIRE MESHING ABOVE POWER HOUSE ROOF
LOOSE BLOCK
LOOSE WOOD OVERHANG OF FACE WALK
POWER HOUSE
FAULT
0 1 2 3 4 5 6 7 8 9 10
METRES
(APPROXIMATE SCALE)

LEGEND

LOOSE BLOCK - PARTIALLY OR COMPLETELY SEPARATED FROM THE ROCK FACE

6735 RD

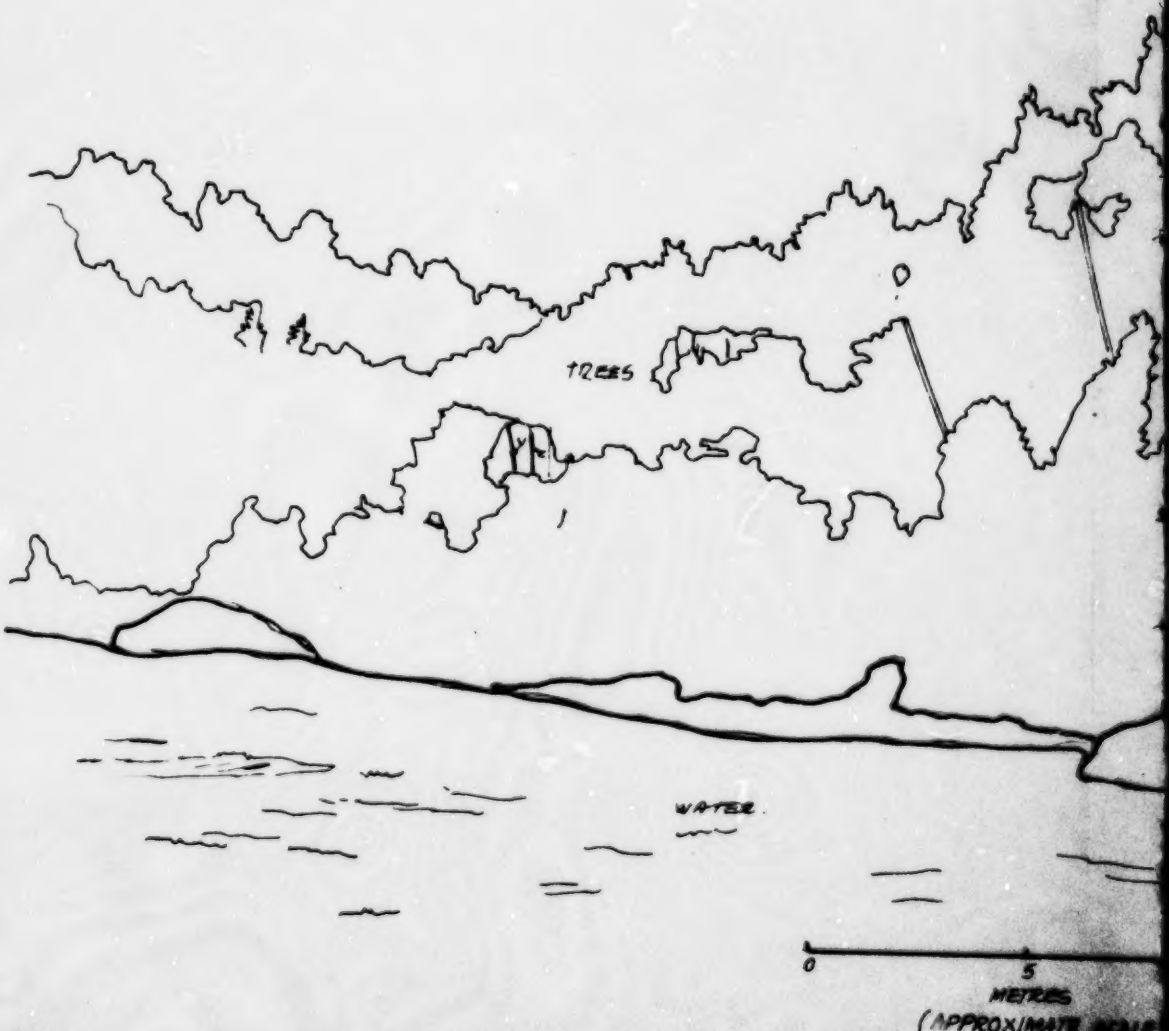
TREES
TALUS
TALUS
VALLEY, POSSIBLE SLIDE AREA
OLD SLIDE AREA
OLD SLIDE AREA
0
5
10
METRES
(APPROXIMATE SCALE)
LEGEND:
LOOSE BLOCK - PARTIALLY OR COMPLETELY SEPARATED FROM THE ROCK FACE.
QUESTIONABLE BLOCK - PROTRUDING BLOCK WHICH MAY OR MAY NOT BE SEPARATED FROM THE MAIN ROCK FACE.



SHEET-E5
ABITIBI CANYON G S
EAST TAILRACE WALL

OLD SLIDE AREA
LOOSE BLOCKS
VALLEY
QUESTIONABLE BLOCKS
FAULT
POWER HOUSE

6738 RD


TREES
WATER
0
5
METRES
(APPROXIMATE SCALE

LOOSE BLOCK

QUESTIONABLE BLOCK

ROCK SLIDE

SMALL ROCK SLIDE

TALUS

TALUS

WATER

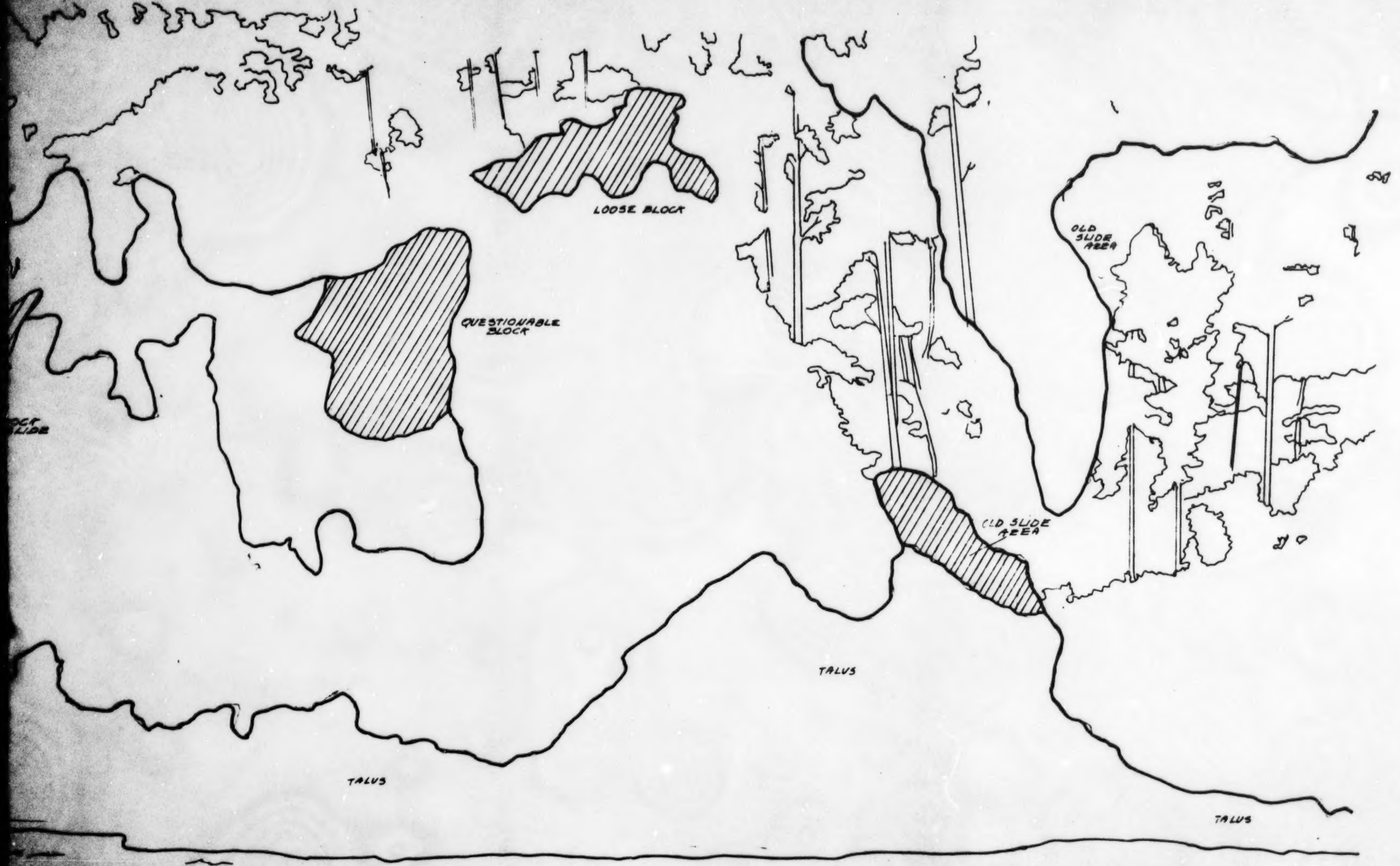
0 5 10
METRES
(APPROXIMATE SCALE)

SHEET-E6

ABITIBI CANYON G S

EAST TAILRACE WALL

LEGEND:
LOOSE BLOCK - PARTIALLY OR COMPLETELY SEPARATED FROM THE ROCK
QUESTIONABLE BLOCK - PROTRUDING BLOCK OR MAY NOT BE SEPARATED MAIN ROCK FACE.



SHEET-E6

CANYON G S

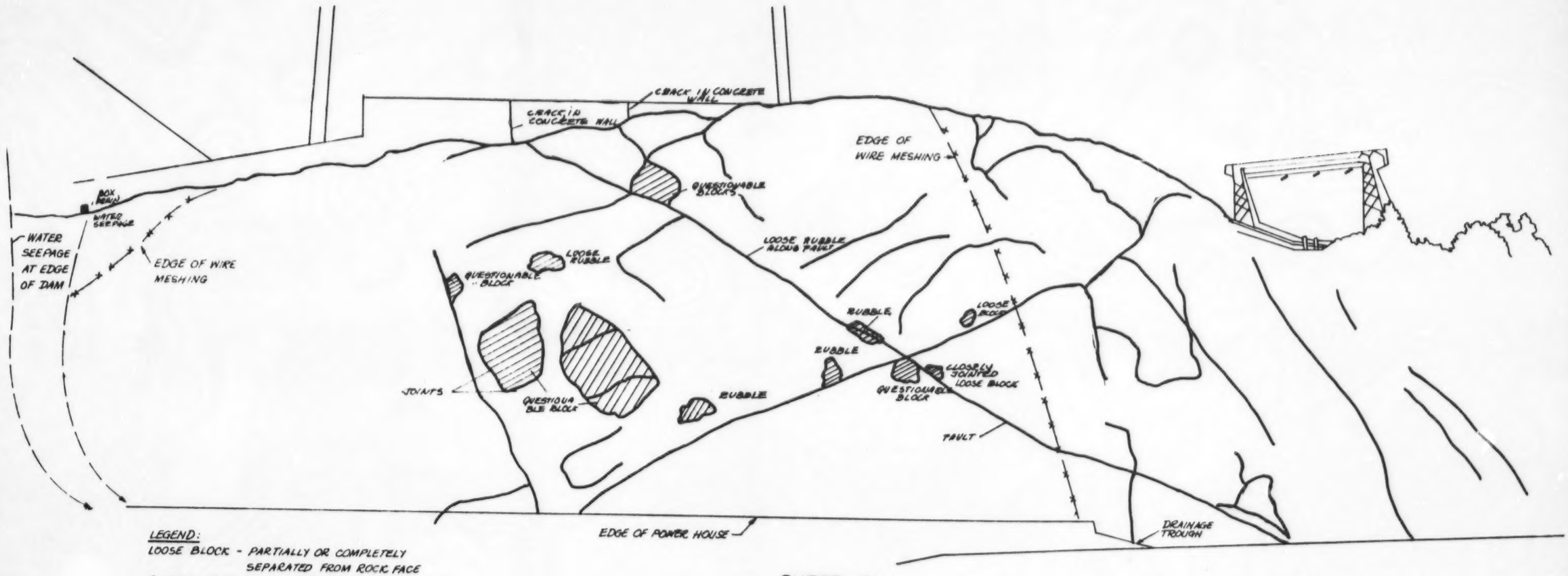
RACE WALL

LEGEND:

LOOSE BLOCK- PARTIALLY OR COMPLETELY SEPARATED FROM THE ROCK FACE

QUESTIONABLE BLOCK - PROTRUDING BLOCK WHICH MAY OR MAY NOT BE SEPARATED FROM THE MAIN ROCK FACE.

6737 ED.



LEGEND:

LOOSE BLOCK - PARTIALLY OR COMPLETELY SEPARATED FROM ROCK FACE

QUESTIONABLE BLOCK - PROTRUDING BLOCK WHICH MAY OR MAY NOT BE SEPARATED FROM THE MAIN ROCK FACE.

SHEET - WI

ABITIBI CANYON GS

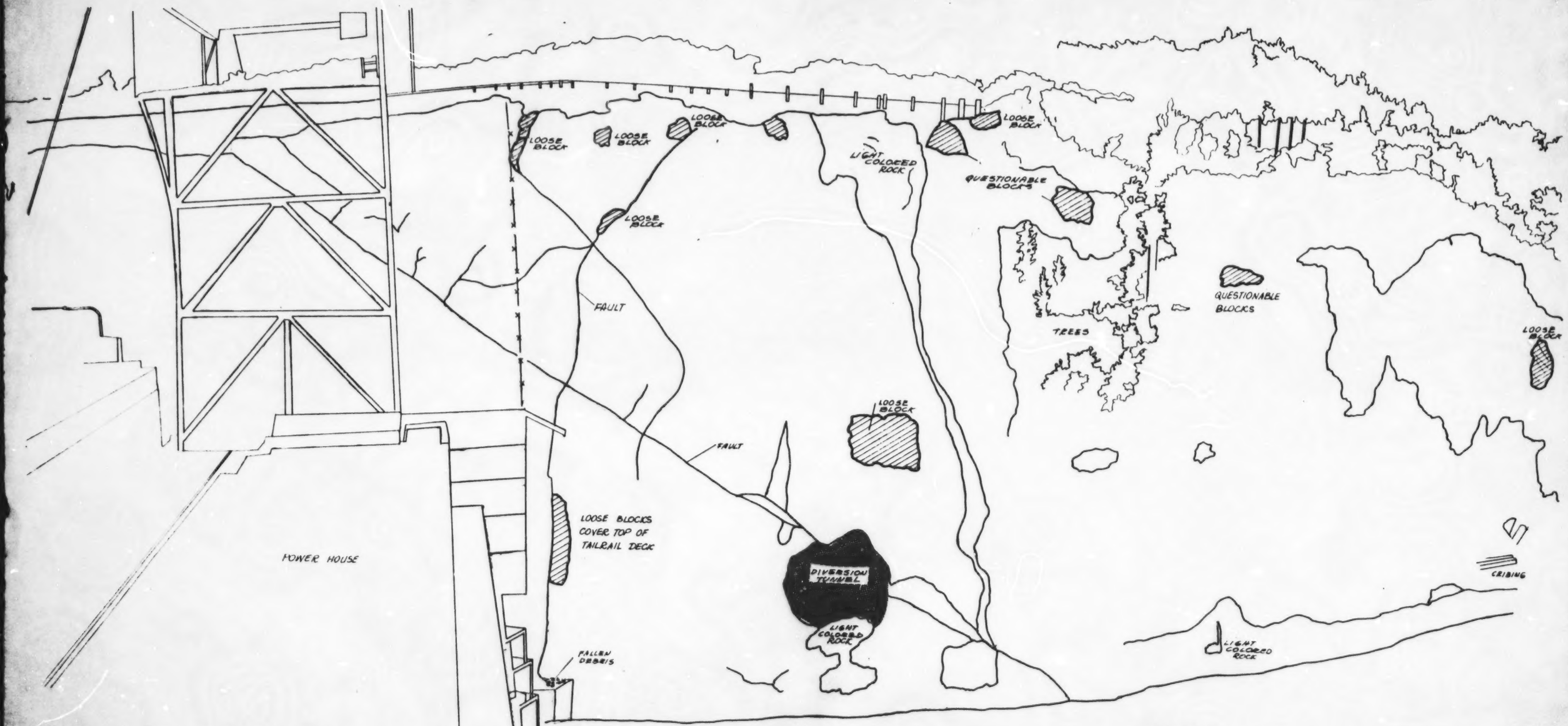
WEST POWERHOUSE WALL

0 1 2 3 4 5

METRES

(APPROXIMATE SCALE)

6739 ED.



LEGEND:

LOOSE BLOCK - PARTIALLY OR COMPLETELY SEPARATED FROM THE ROCK FACE

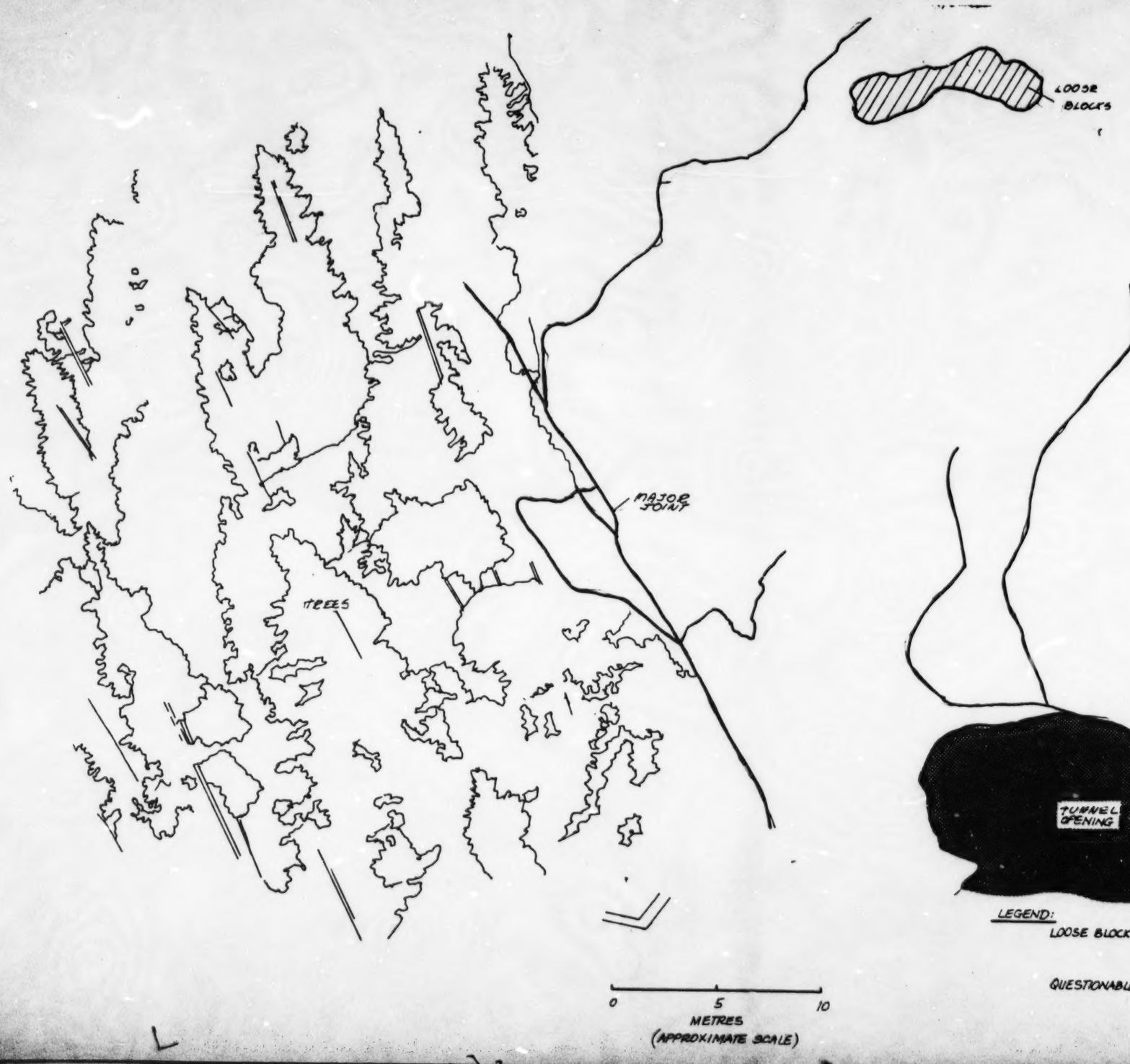
QUESTIONABLE BLOCK - PROTRUDING BLOCK WHICH MAY OR MAY NOT BE SEPARATED FROM THE MAIN ROCK FACE

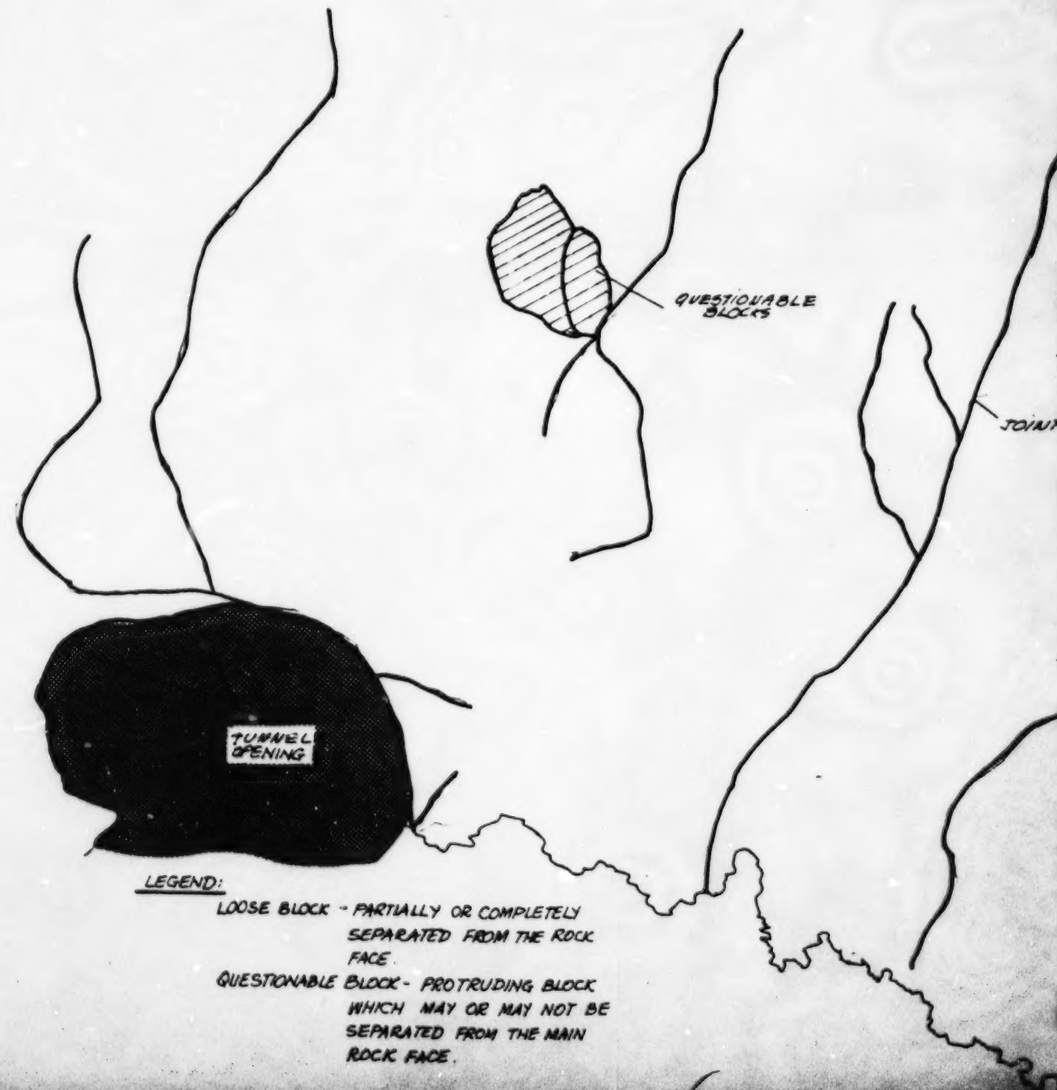
SHEET - W2

ABITIBI CANYON G S

POWERHOUSE WEST SIDE

6736 2D

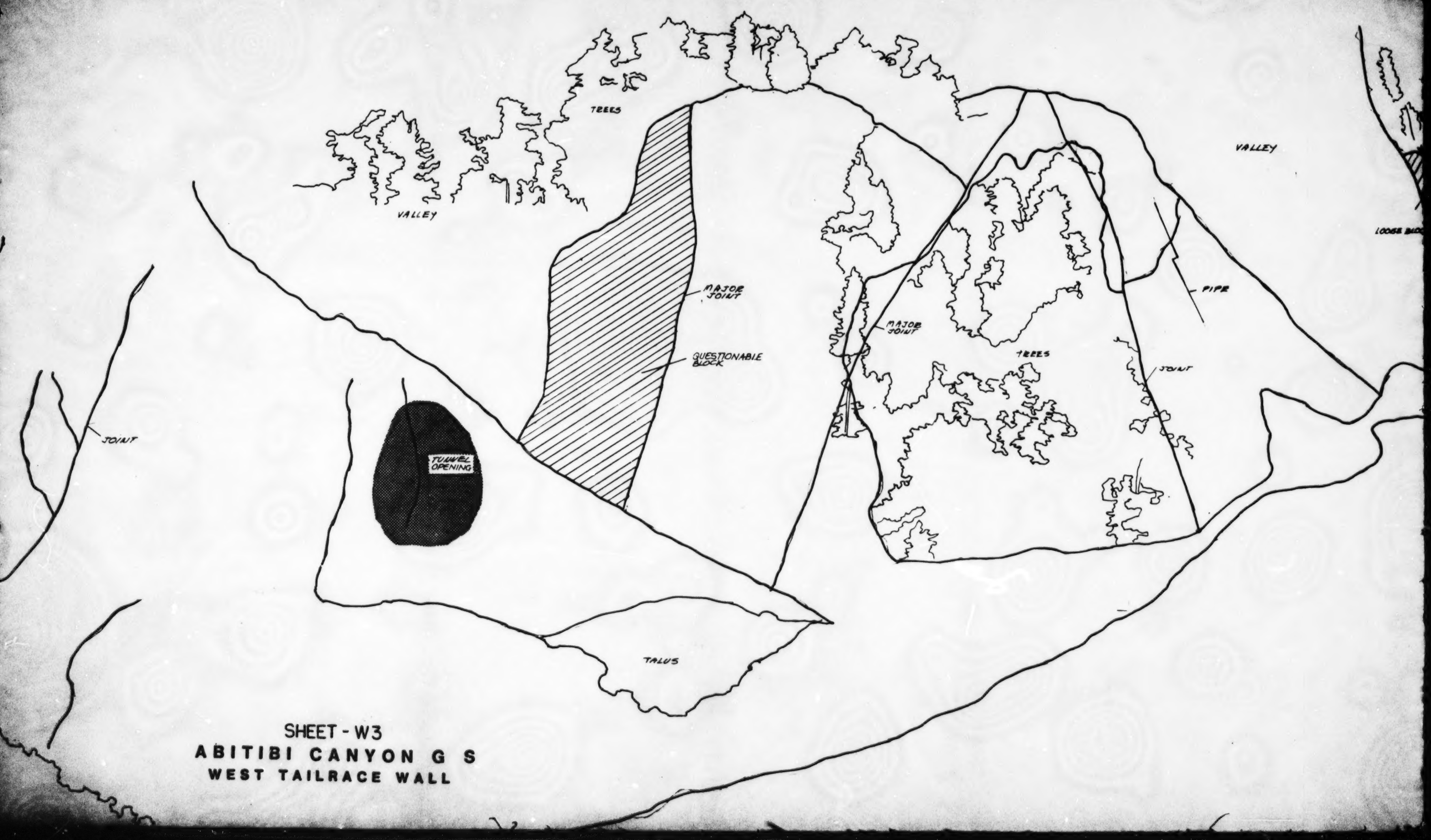




LEGEND:

LOOSE BLOCK - PARTIALLY OR COMPLETELY SEPARATED FROM THE ROCK FACE.

QUESTIONABLE BLOCK - PROTRUDING BLOCK WHICH MAY OR MAY NOT BE SEPARATED FROM THE MAIN ROCK FACE.

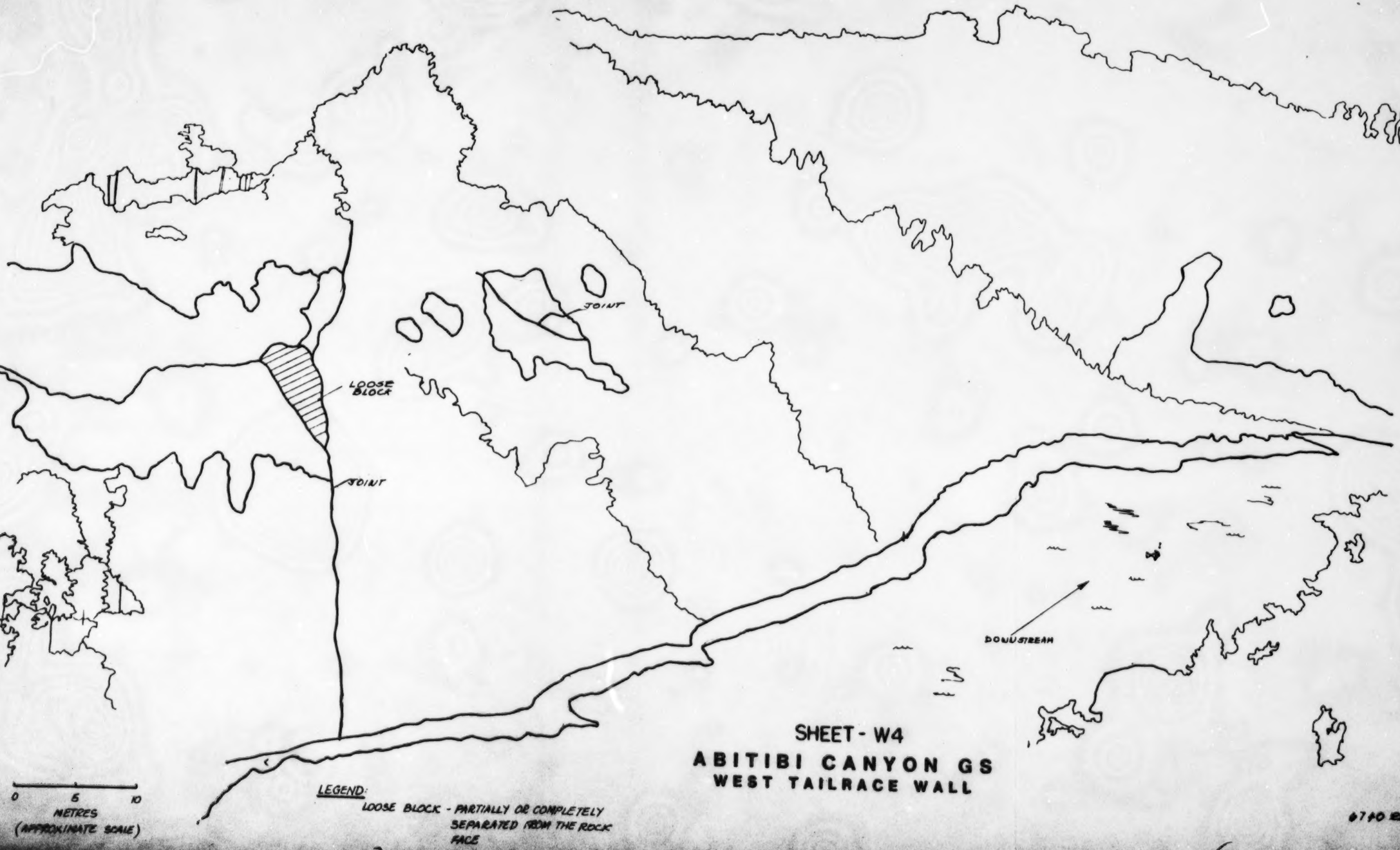


SHEET - W3

ABITIBI CANYON G S

WEST TAILRACE WALL

6741 KD



SHEET - W4

ABITIBI CANYON GS
WEST TAILRACE WALL

6740 RD